Drop Size Spectra - Micronair AU5000 Atomizer And Hollow Cone Nozzles With Special Tank Mix

Forest Service

Forest Pest
Management
2810 Chiles Rd., Ste. B
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PREFACE

The purpose of this wind tunnel test was to establish atomization characteristics of special aerially applied tank mixes used in a sub-study of Program WIND. The objective of the sub-study was to compare different application techniques (nozzles and aircraft) to canopy penetration and spray deposition on manikins and equipment. Drop spectra of sprays must be determined at the nozzle where atomization occurs. This then makes it possible to establish base-lines and to evaluate nozzles on a comparative bases. Another important use of these data is as input to spray dispersion models which predict the dispersion of sprays. Spray dispersion models move each drop size through the atmosphere; therefore, for effective predictions it is essential to know the drop spectra of the tank mix.

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Introduction:

Tests were conducted in a wind tunnel to measure the drop size spectra from a D2-45 hollow cone nozzle and a D4-45 hollow cone nozzle with a tank mixture of 10 lbs. of technical grade Manganese sulfate ($MnSO_4$) plus 48 oz. Rhodamine BX dye in 100 gal. of water. Also a Micronair AU500 rotary atomizer was tested with a tank mixture of 10 lbs. technical grade $MnSO_4$ plus 3 oz. Nalco-Trol plus 48 oz. Rhodamine BX dye in 100 gal. water.

Equipment:

The tests were conducted in a wind tunnel at the University of California, Department of Agricultural Engineering. The wind tunnel has a test section 8 ft. long and a 2 x 2 ft. cross section. A Particle Measurement System (PMS) probe, OAP-2D-GA1, with a PMS 11-C data acquisition system was used to measure the drop size spectra. The probe has a nominal class size of 33 μm. The system counts and classifies the drops into 62 size classes from 28 to 2062 μm.

Procedures:

The drop size spectra was measured from a D2-45 hollow cone nozzle directed with the airstream at an airspeed of 25 mph and a D4-45 hollow cone nozzle directed with the airstream at 17 mph, Table I. We were unable to perform tests with the nozzles directed 90° to the airstream because the tunnel velocity was not sufficient to turn the particles with the direction of the airflow before they struck the bottom of the tunnel. We feel, however, that the particle size would not be significantly different at such a low airspeed velocity. The nozzles were mounted on a microprocessor controlled mechanism that could move the nozzle to scan the entire spray pattern.

The drop size measurement procedures for the Micronair AU5000 atomizer were similar to protocol developed for testing rotary atomizers described in earlier Forest Pest Management reports by the same authors. Briefly, the PMS probe was mounted in the wind tunnel with the laser beam located 5.25 inches

above the bottom of the wind tunnel test section and 12" downstream from the rear of the rotary atomizer. The atomizer was mounted on an adjustable vertical shaft such that the unit could be moved to a series of radial distances from the laser beam. Sample positions were calculated based on radial locations to represent the center of equal size sample areas. A single nozzle test involved taking a sample at six to nine sample positions, based on the size of the spray pattern. The reports for the different positions were combined into one composite pattern that represents the overall temporal drop size distribution for the atomizer. The Micronair AU5000 rotary atomizer was tested at an airspeed of 95 mph and blade angle of 40°, Table II.

Results:

Table III is a summary of the drop size spectra for the two formulations. The nomenclature used is as follows:

$D_{V.1}$ = Diameter that contains 10% of volume in drops of smaller size.

$D_{V.5}$ = Diameter that contains 50% of volume in drops of smaller size.

(Volume median diameter)

$D_{V.9}$ = Diameter that contains 90% of volume in drops of smaller size.

$$\text{Relative Span} = \text{R.S.} = \frac{D_{V.9} - D_{V.1}}{D_{V.5}}$$

The appendix contains the complete results of the drop size frequency data, statistical results and graphs for each of the 3 tests.

Summary:

Three tests were conducted using two hollow cone nozzles, a D2-45, D4-45 and a Micronair AU5000 Spinner. The two tests using the hollow cone nozzles were conducted using a tank mixture of 10 lbs. technical grade $MnSO_4$ plus 48 oz. Rhodamine BX dye in 100 gal. water. The test using the Micronair was conducted with a tank mix of 10 lbs. technical grade $MnSO_4$ plus 3 oz. of Nalco-Trol plus 48 oz. Rhodamine BX dye in 100 gal. water.

The drop size from the hollow cone nozzles are very similar to the previous tests with water (MEDC Report Measurement of Drop Size Frequency From Nozzles Used For Aerial Application Of Pesticides In Forests, Oct. 1984, Missoula, MT.). For example, results with the D4-45 nozzle at 40 psi, 0^{o}, and 100 mph airstream with water produced a $D_{V.5}$ of 255 µm compared to 264 µm for the same nozzle with the $MnSO_4$ mixture and an airspeed of 95 mph. The AU5000 at 100 mph with water at 3 gpm and a blade angle of 35^{o}, and 8000 rpm produced a $D_{V.5}$ of 118 µm. The test in this report had several different conditions, i.e., 95 mph airspeed, 5.9 gpm, 40^{o} blade angle, 5575 rpm and a mixture of $MnSO_4$ and Nalco-Trol. As expected, the $D_{V.5}$ was somewhat larger, 189 µm, compared to the above test with water.

[illegible] drop size from the hollow cone nozzles are very similar to the previous [illegible] for [illegible] Report *Measurement of Drop Size Frequency From* [illegible] *Aerial Application Of Pesticides to Forests*, Oct. 1984, MI-- [illegible] sample, results with the D6-45 [illegible] at 40 psi, [illegible] and [illegible] mph [illegible] produced [illegible] $D_{V.5}$ [illegible] compared to 264 um for the [illegible] MnSO$_4$ mixture and an airspeed of 95 mph. The AU5000 [illegible] 3 [illegible] a blade angle of [illegible] rpm [illegible] duced [illegible] ter in this [illegible] ort had several [illegible] conditions, i.e., [illegible] on mixture [illegible] 40^0 blade angle, 5575 rpm and [illegible] mixture of MnSO$_4$ and Falco-Trol. [illegible] ted, the $D_{V.5}$ was somewhat larger, 189 um, compared to [illegible]

Table I

Test conditions for drop size measurements with the hollow cone nozzles.

Nozzle Type	Airspeed mph	Flowrate gpm	Pressure psi
D2-45	25	0.20	40
D4-45	17	0.47	70

Table II

Test conditions for drop size measurements with the rotary atomizer.

Atomizer Type	Airspeed mph	VRU Setting	Pressure psi	Flowrate gpm	Blade Angle	RPM
Micronair AU5000	95	13	50	5.9	40°	5575

Table III

Summary of drop size spectrum from the three atomizers with selected mixtures.

Atomizer Type	Tank Mixture	Drop size, μm $D_{V.1}$	$D_{V.5}$	$D_{V.9}$	R.S.
D2-45	10 lbs $MnSO_4$ + 48 oz. Rh BX dye per 100 gal. H_2O	141	251	382	0.96
D4-45	10 lbs $MnSO_4$ + 48 oz. Rh BX dye per 100 gal. H_2O	138	264	410	1.03
Micro-nair	10 lbs $MnSO_4$ + 48 oz. Rh BX dye + 3 oz NalcoTrol per 100 gal. H_2O	104	189	307	1.07

Table I

Conditions for dyeing nylon measurements with the Bellair dyeing apparatus.

Dyestuff	Amount used	Liquor ratio	Time	Temperature
Alizarine Saphirol B	0.20 gm.	40	1 hr.	85° C.

Table II

Conditions for dyeing nylon with the Pecora [illegible].

Dyestuff	Amount used	Liquor ratio	Time	Temperature	Blank Analysis
Alizarine Saphirol B	0.20 gm.	40	1 hr.	85° C.	[illegible]

Table III

[illegible] dye stock solutions from the three colorimeters with selected wavelengths.

Dyestuff	Tank Mixture	Dyes III			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10 lbs $MgSO_4$ + 43 oz. [illegible] per 100 gals. H_2O	[illegible]	141	231	383	0.89
10 lbs $MgSO_4$ + 43 oz. [illegible] per 100 gals. H_2O	[illegible]	[illegible]	[illegible]	[illegible]	1.63
0 lbs $MgSO_4$ + 23 oz. [illegible] + [illegible] per 100 gals. H_2O	[illegible]	[illegible]	[illegible]	[illegible]	1.07

TABLE IV

Droplet spectra for D2-45 nozzle atomizing $MnSO_4$, Rhodamine BX, and water.

Nozzle	D2-45	Slice Rate	.75MHz
Angle to Airstream	0 degrees	AVG	100
Spray Pressure	40 psi	DFM	1 cm.
Airspeed	25 mph	BAR	1.5
Flow Rate	0.20 gpm	Distance to Probe	41 cm.
Tank Mix	10# Mn/100 gal H2O	Sample Interval	600 sec.
		Number of Samples	1
		Number of Scans	16
FILE: C:\PMS\DATA\100385.001		Scan Spacing	2.3 cm.
Number of Tests Combined: 1		Scan Length	36.8 cm.

UPPER LIMIT	N(RAW)	N/SEC	Gm/SEC	% N	% VOL.	ACCUMULATED % N	ACCUMULATED % VOL.
56	3165	1.79E+06	0.06	32.30	0.46	32.30	0.46
89	7248	664949	0.13	12.02	1.03	44.32	1.49
122	9442	741717	0.45	13.41	3.52	57.73	5.01
154	11436	776556	1.06	14.04	8.30	71.77	13.30
187	9906	547396	1.42	9.90	11.06	81.66	24.36
220	7907	366417	1.60	6.62	12.51	88.29	36.88
252	6249	259948	1.77	4.70	13.83	92.99	50.70
284	4256	163589	1.64	2.96	12.83	95.94	63.53
318	2801	105922	1.52	1.91	11.89	97.86	75.42
351	1534	56879	1.11	1.03	8.68	98.89	84.10
382	857	31870	0.81	0.58	6.35	99.46	90.45
414	408	16292	0.54	0.29	4.19	99.76	94.64
447	165	6508	0.27	0.12	2.12	99.88	96.76
479	93	4063	0.21	0.07	1.64	99.95	98.40
512	42	1785	0.11	0.03	0.89	99.98	99.29
545	14	513	0.04	0.01	0.31	99.99	99.60
578	2	171	0.02	0.00	0.12	99.99	99.72
611	2	214	0.02	0.00	0.18	100.00	99.90
644	2	96	0.01	0.00	0.10	100.00	100.00
TOTAL	6.55E+04	5.53E+06	12.81				

TOTAL ACCEPTED RAW PARTICLES / TOTAL IMAGES = 65529/ 43175 =151.8%

NUMBER MEAN DIA.= D_{10}.... 117.88 µm
VOLUME MEAN DIA.= D_{30}.... 164.21 µm
SAUTER MEAN DIA.= D_{32}.... 218.61 µm

NUMBER MEDIAN DIA.= $D_{N.1}$... <56 µm
$D_{N.5}$... 102.92 µm
$D_{N.9}$... 231.52 µm

VOLUME MEDIAN DIA.= $D_{V.1}$... 141.46 µm
$D_{V.5}$... 250.83 µm
$D_{V.9}$... 381.54 µm

RELATIVE SPAN= 0.96

Nozzle Type . . . D2-45
Angle to Airstream 0°
Spray Pressure . . 40 psi
Airspeed . . . . . 25 mph
Flow Rate . . . . 0.20 gpm
Tank Mix: 10# Mn/100 gal H20

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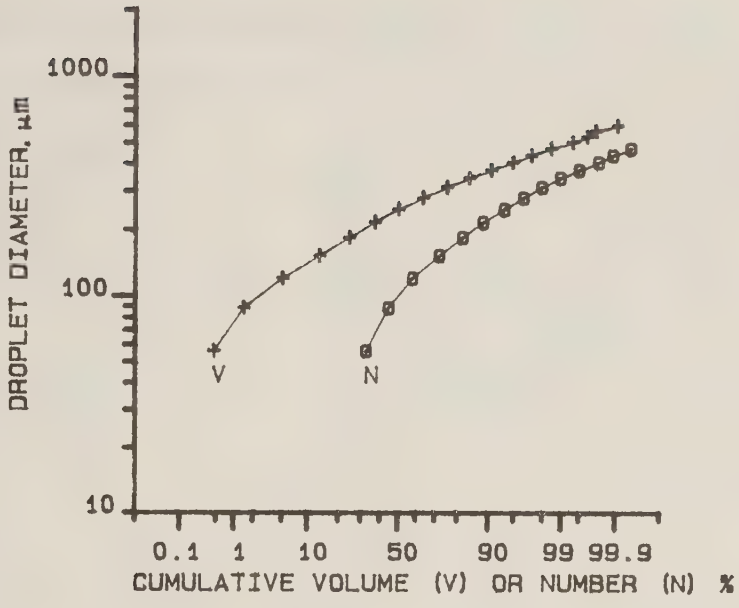

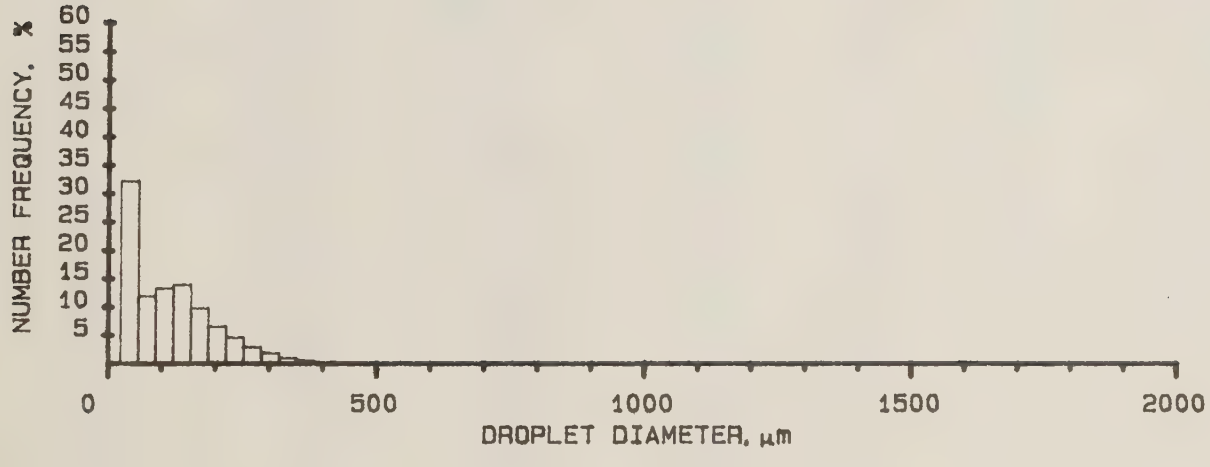

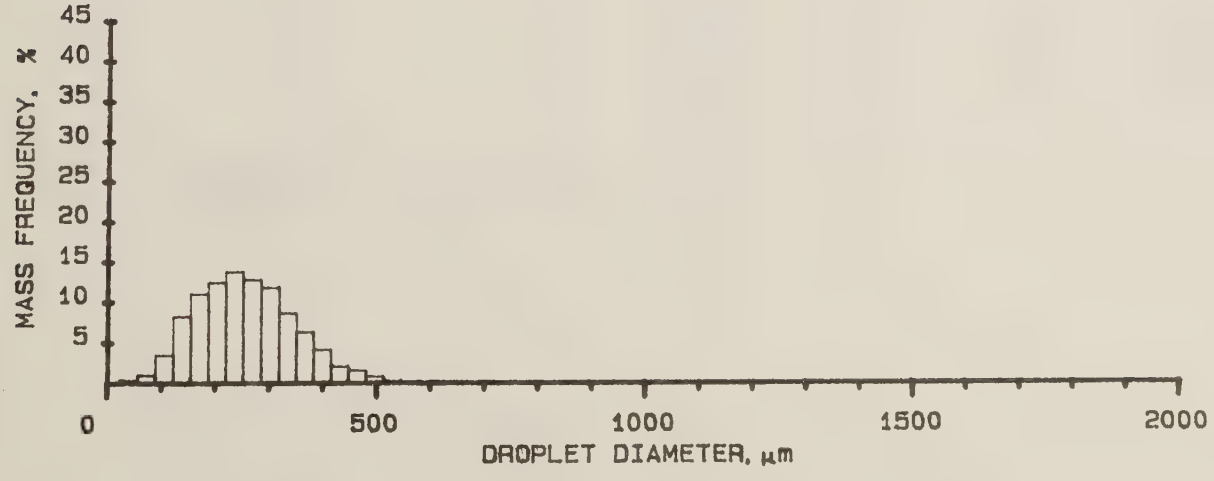

Figure I - Droplet spectra data for a D2-45 nozzle atomizing $MnSO_4$, Rhodamine BX, and water.

TABLE V

Droplet spectra for D4-45 nozzle atomizing $MnSO_4$, Rhodamine BX, and water.

Nozzle	D4-45	Slice Rate	.75MHz
Angle to Airstream	0 degrees	AVG	100
Spray Pressure	70 psi	DFM	1 cm.
Airspeed	17 mph	BAR	1.5
Flow Rate	.47 gpm	Distance to Probe	30 cm.
Tank Mix	10# Mn/100 gal H2O	Sample Interval	600 sec.
		Number of Samples	1
		Number of Scans	16
FILE: C:\PMS\DATA\10048510.002		Scan Spacing	2.3 cm.
Number of Tests Combined: 2		Scan Length	36.8 cm.

UPPER LIMIT	N(RAW)	N/SEC	Gm/SEC	% N	% VOL.	ACCUMULATED % N	ACCUMULATED % VOL.
56	7295	8.81E+06	0.29	46.63	0.87	46.63	0.87
89	12355	2.48E+06	0.49	13.10	1.47	59.73	2.34
122	11277	2.19E+06	1.33	11.57	3.96	71.30	6.30
154	9105	1.80E+06	2.46	9.52	7.35	80.82	13.65
187	6652	1.18E+06	3.05	6.24	9.10	87.05	22.75
220	5331	817821	3.58	4.33	10.69	91.38	33.44
252	4190	587418	4.00	3.11	11.95	94.49	45.39
284	2948	402517	4.04	2.13	12.07	96.62	57.46
318	2057	266388	3.83	1.41	11.44	98.03	68.90
351	1232	175875	3.44	0.93	10.27	98.96	79.17
382	667	88473	2.26	0.47	6.75	99.43	85.92
414	363	49423	1.63	0.26	4.86	99.69	90.78
447	191	30215	1.26	0.16	3.76	99.85	94.54
479	83	14598	0.76	0.08	2.26	99.93	96.80
512	39	6545	0.42	0.03	1.24	99.96	98.04
545	18	3831	0.29	0.02	0.88	99.98	98.92
578	7	1438	0.13	0.01	0.40	99.99	99.32
611	6	1570	0.17	0.01	0.51	100.00	99.83
644	1	392	0.05	0.00	0.15	100.00	99.98
677	0	0	0.00	0.00	0.00	100.00	99.98
710	0	0	0.00	0.00	0.00	100.00	99.98
743	0	0	0.00	0.00	0.00	100.00	99.98
776	0	0	0.00	0.00	0.00	100.00	99.98
809	1	24	0.01	0.00	0.02	100.00	100.00
TOTAL	6.38E+04	1.89E+07	33.49				

TABLE V (continued)

TOTAL ACCEPTED RAW PARTICLES / TOTAL IMAGES = 63818/ 60054 =106.3%

NUMBER MEAN DIA.=	D_{10}....	97.29 µm
VOLUME MEAN DIA.=	D_{30}....	150.20 µm
SAUTER MEAN DIA.=	D_{32}....	220.29 µm

	$D_{N.1}$...	<56 µm
NUMBER MEDIAN DIA.=	$D_{N.5}$...	<56 µm
	$D_{N.9}$...	209.38 µm

	$D_{V.1}$...	138.22 µm
VOLUME MEDIAN DIA.=	$D_{V.5}$...	264.40 µm
	$D_{V.9}$...	409.72 µm

R.S.... 1.03

Nozzle Type . . . D4-45
Angle to Airstream 0°
Spray Pressure . . 70 psi
Airspeed . . . . . 17 mph
Flow Rate . . . . .47 gpm
Tank Mix: 10# Mn/100 gal H20

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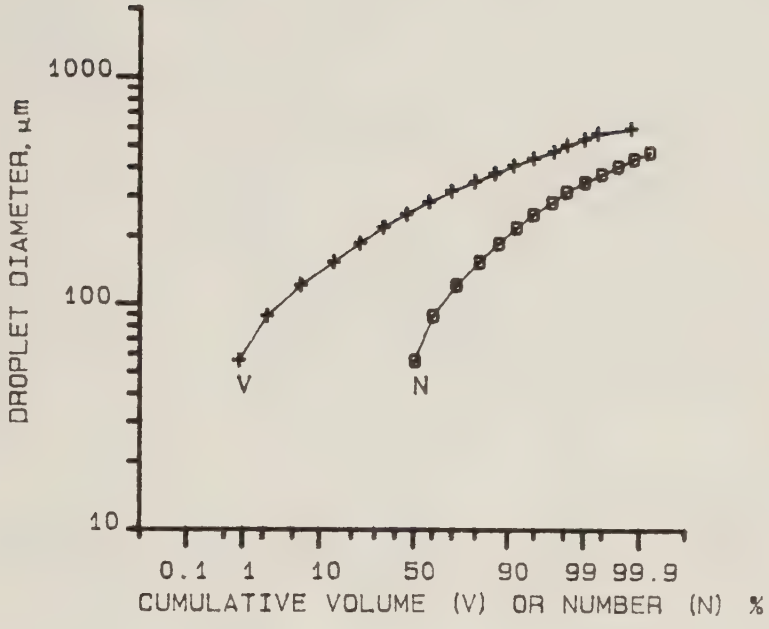
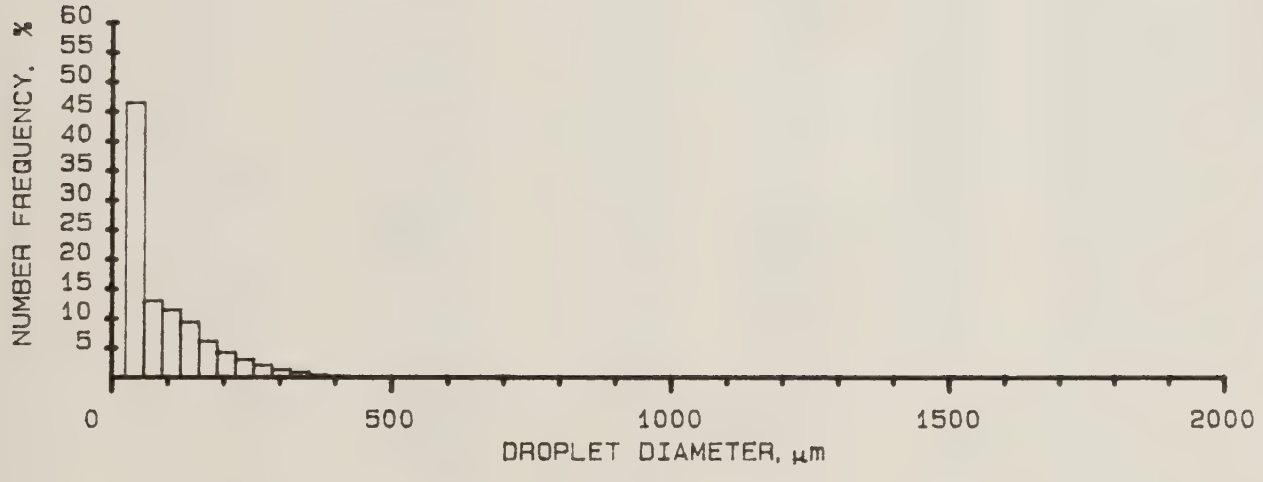




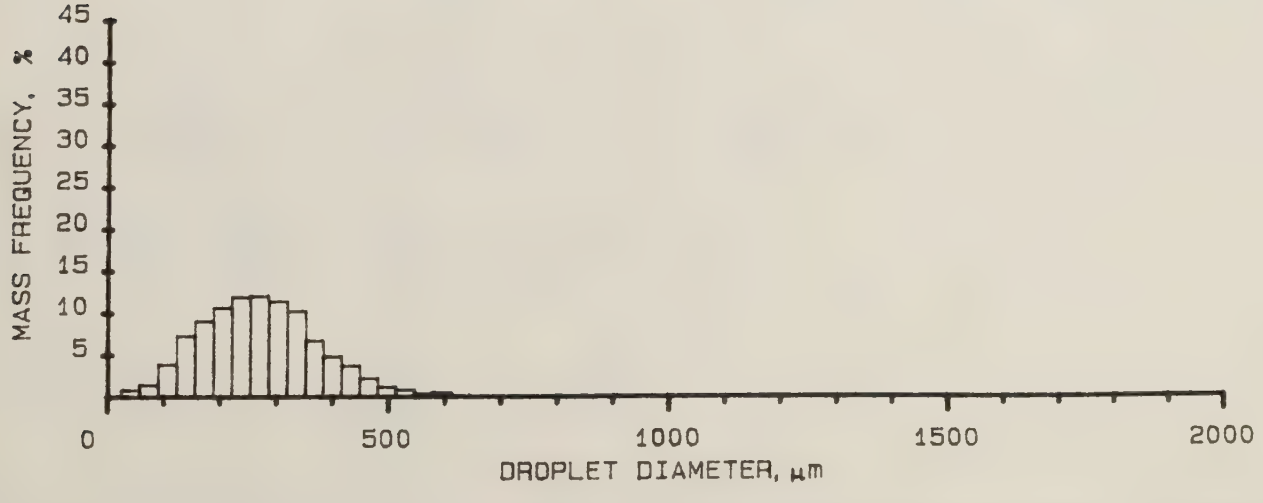


Figure II - Droplet spectra data for a D4-45 nozzle atomizing $MnSO_4$, Rhodamine BX, and water.

TABLE VI

Droplet Spectra for Micronair AU5000 rotary atomizer atomizing a tank mix of $MnSO_4$, Rhodamine BX, Nalco-Trol, and water.

Nozzle	AU5000	Slice Rate	3 MHz
RPM	5575	AVG	20000
Spray Pressure	50 psi	DFM	1 cm.
Airspeed	95 mph	BAR	1.5
Flow Rate	5.9 gpm	Distance to Probe	32 cm.
Tank Mix	10# Mn,3 oz NALCO/ 100 GAL H2O	Sample Interval	60 sec.
		Number of Samples	1
FILE: C:\PMS\DATA\10028515.002		Number of Sample Rings	8

Number of Tests Combined:2

UPPER LIMIT	N(RAW)	N/SEC	Gm/SEC	% N	% VOL.	ACCUMULATED % N	ACCUMULATED % VOL.
56	8705	2.37E+08	7.81	54.06	2.26	54.06	2.26
89	9742	6.07E+07	12.07	13.83	3.50	67.90	5.77
122	8710	5.19E+07	31.53	11.83	9.14	79.72	14.91
154	9762	4.13E+07	56.58	9.42	16.41	89.14	31.32
187	9960	2.39E+07	61.77	5.44	17.91	94.58	49.23
220	8141	1.19E+07	52.27	2.72	15.16	97.30	64.39
252	6587	6.28E+06	42.78	1.43	12.41	98.73	76.80
284	4594	3.38E+06	33.92	0.77	9.84	99.50	86.64
318	1970	1.18E+06	16.98	0.27	4.92	99.77	91.56
351	939	494299	9.67	0.11	2.80	99.88	94.36
382	541	233360	5.96	0.05	1.73	99.93	96.09
414	313	126749	4.17	0.03	1.21	99.96	97.30
447	208	75309	3.14	0.02	0.91	99.98	98.21
479	136	40484	2.10	0.01	0.61	99.99	98.82
512	91	30431	1.93	0.01	0.56	100.00	99.38
545	33	7428	0.57	0.00	0.17	100.00	99.55
578	23	7641	0.71	0.00	0.20	100.00	99.75
611	7	1370	0.15	0.00	0.04	100.00	99.79
644	11	4974	0.64	0.00	0.19	100.00	99.98
677	0	234	0.04	0.00	0.01	100.00	99.99
710	1	180	0.03	0.00	0.01	100.00	100.00
TOTAL	7.05E+04	4.39E+08	344.81				

TOTAL ACCEPTED RAW PARTICLES / TOTAL IMAGES = 70474/ 96924 = 72.7%

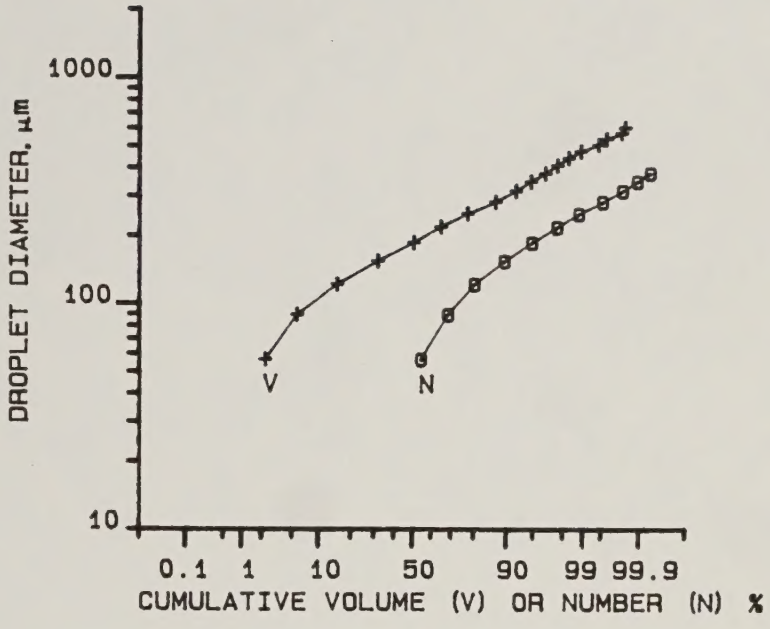
NUMBER MEAN DIA.= $D_{1.0}$... 78.82 µm
VOLUME MEAN DIA.= $D_{3.0}$... 114.51 µm
SAUTER MEAN DIA.= $D_{3.2}$... 161.62 µm

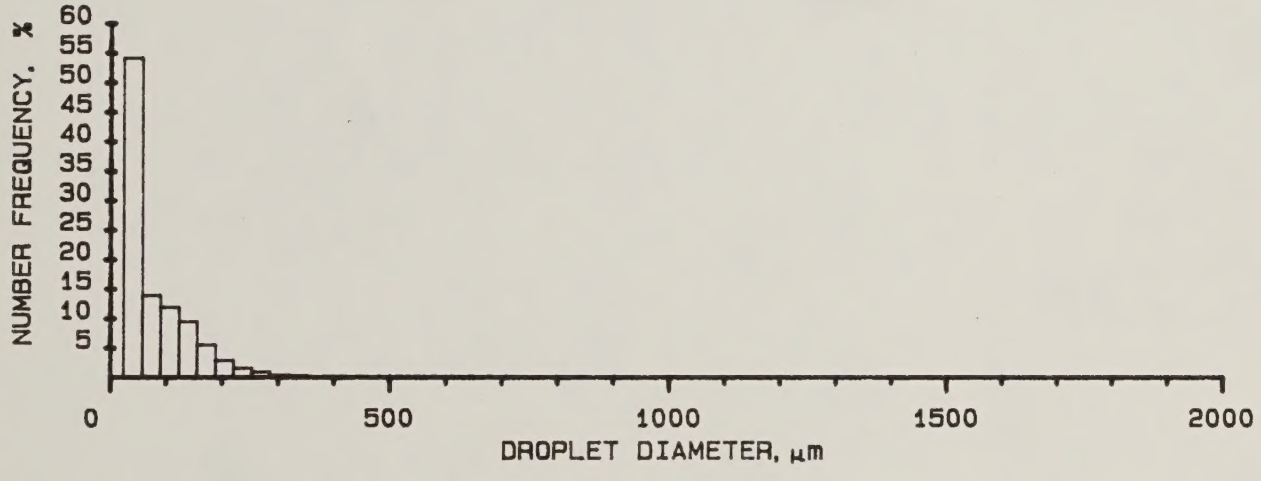
NUMBER MEDIAN DIA.= $D_{N.1}$... <56 µm
$D_{N.5}$... <56 µm
$D_{N.9}$... 159.52 µm

VOLUME MEDIAN DIA.= $D_{V.1}$... 104.22 µm
$D_{V.5}$... 188.57 µm
$D_{V.9}$... 306.85 µm

RELATIVE SPAN= 1.07

Nozzle Type . . . AU5000
RPM 5575
Spray Pressure . . 50 psi
Airspeed . . . . . 95 mph
Flow Rate . . . . 5.9 gpm
Tank Mix: 10# Mn, 3 oz NALCO/
100 GAL H2O
FILE: C: \PMS\DATA\10028515.002





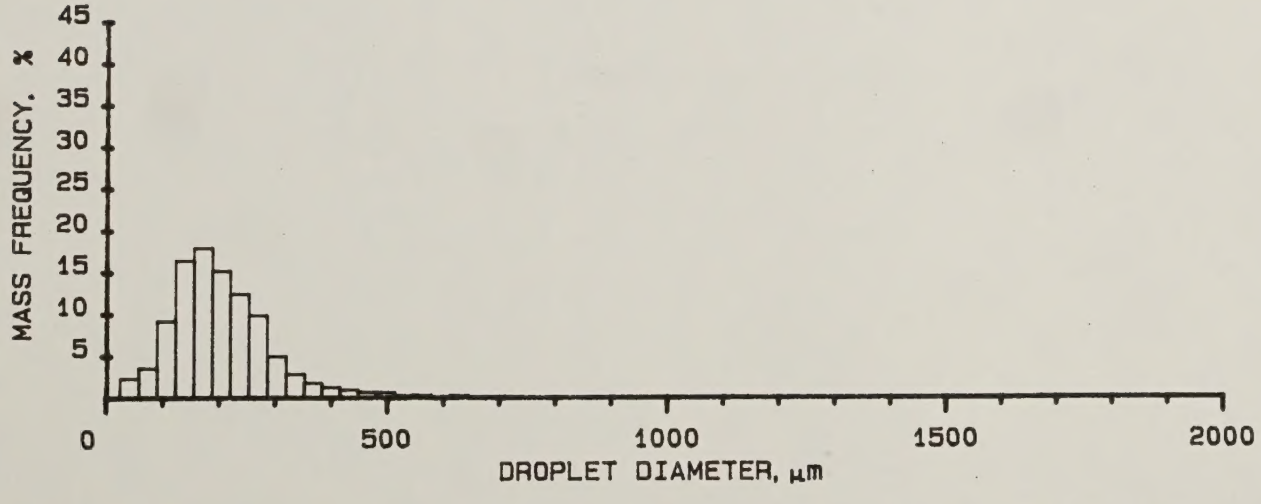


Figure III - Droplet spectra data for Micronair AU5000 rotary atomizer atomizing $MnSO_4$, Rhodamine BX, Nalco-Trol, and water.